

A

BIRCH, STEWART, KOLASCH & BIRCH, LLP

TERRELL C. BIRCH
RAYMOND C. STEWART
JOSEPH A. KOLASCH
JAMES M. SLATTERY
BERNARD L. SWEENEY*
MICHAEL K. MUTTER
CHARLES GORENSTEIN
GERALD M. MURPHY, JR.
LEONARD R. SVENSSON
TERRY L. CLARK
ANDREW D. MEIKLE
MARC S. WEINER
JOE McKINNEY MUNCY
ROBERT J. KENNEY
DONALD J. DALEY
JOHN W. BAILEY
JOHN A. CASTELLANO, III
OF COUNSEL:
HERBERT M. BIRCH (1905-1996)
ELLIOT A. GOLDBERG*
WILLIAM L. GATES*
EDWARD H. VALANCE
RUPERT J. BRADY (RET.)*
*ADMITTED TO A BAR OTHER THAN VA

INTELLECTUAL PROPERTY LAW
8110 GATEHOUSE ROAD
SUITE 500 EAST
FALLS CHURCH, VA 22042-1210
USA

(703) 205-8000

FAX: (703) 205-8050
(703) 698-8590 (G IV)

e-mail: mailroom@bskb.com
web: http://www.bskb.com

CALIFORNIA OFFICE
650 TOWN CENTER DRIVE, SUITE 1120
COSTA MESA, CA 92626-7125

GARY D. YACURA
THOMAS S. AUCHTERLONIE
MICHAEL R. CAMMARATA
JAMES T. ELLER, JR.
SCOTT L. LOWE
MARY ANN CAPRIA
MARK J. NUEL, PH.D.
DARIN E. BARTHOLOMEW*
D. RICHARD ANDERSON
PAUL C. LEWIS
W. KARL RENNER
MARK W. MILSTEAD*
JOHN CAMPA*
REG. PATENT AGENTS.
FREDERICK R. HANDREN
ANDREW J. TELESZ, JR.
MARYANNE ARMSTRONG, PH.D.
MAKI HATSUMI
MIKE S. RYU
CRAIG A. McROBBIE
GARTH M. DAHLEN, PH.D.
LAURA C. LUTZ
ROBERT E. GOOZNER, PH.D.
HYUNG N. SOHN
MATTHEW J. LATTIG
ALAN PEDERSEN-GILES
JUSTIN D. KARJALA

01/14/00
jc715 U.S. PTO
01/14/00

jc564 U.S. PTO
09/482886
01/14/00

Date: January 14, 2000
Docket No.: 0142-0309P

Assistant Commissioner for Patents
Box PATENT APPLICATION
Washington, D.C. 20231

Sir:

Transmitted herewith for filing is the patent application of

Inventor(s): HOLLANDS, Peter Joseph
ELLENKAMP, Hendrik Willem

For: INKJET PRINTHEAD

Enclosed are:

- ☒ A specification consisting of 7 pages
- ☒ 1 sheet(s) of formal drawings
- ☒ An assignment of the invention
- ☒ Certified copy of Priority Document(s)
- ☒ Executed Declaration ☒ Original ☐ Photocopy
- ☐ A verified statement to establish small entity status under 37 CFR 1.9 and 37 CFR 1.27
- ☐ Preliminary Amendment
- ☒ Information Disclosure Statement, PTO-1449 and reference(s)

Other _____

The filing fee has been calculated as shown below:

LARGE ENTITY				SMALL ENTITY	
FOR	NO. FILED	NO. EXTRA	RATE FEE		RATE FEE
BASIC FEE	***** ***** *****	***** ***** *****	***** ***** \$690.00 *****	or	**** **** \$345.00 ****
TOTAL CLAIMS	7 - 20 =	0	x18 =\$ 0.00	or	x 9 = \$ 0.00
INDEPENDENT	2 - 3 =	0	x78 =\$ 0.00	or	x 39 = \$ 0.00
MULTIPLE DEPENDENT CLAIM PRESENTED <u>no</u>			+260 = \$ 0.00	or	+130 = \$ 0.00
			TOTAL \$ 690.00		TOTAL \$ 0.00

X A check in the amount of \$ 730.00 to cover the filing fee and recording fee (if applicable) is enclosed.

_____ Please charge Deposit Account No. 02-2448 in the amount of \$_____. A triplicate copy of this transmittal form is enclosed.

_____ No fee is enclosed.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies, to charge payment or credit any overpayment to Deposit Account No. 02-2448 for any additional fees required under 37 C.F.R. 1.16 or under 37 C.F.R. 1.17; particularly, extension of time fees.

Respectfully submitted,

BIRCH, STEWART, KOLASCH & BIRCH, LLP

By _____

RAYMOND C. STEWART

Reg. No. 21,066

P. O. Box 747

Falls Church, Virginia 22040-0747

(703) 205-8000
RCS/djm

Océ-Technologies B.V., of Venlo

Inkjet Printhead

5

BACKGROUND OF THE INVENTION

The present invention relates to an ink jet printhead comprising a channel plate having a plurality of ink channels etched into at least one surface thereof, actuators respectively associated with each of the ink channels for pressurizing ink contained in the ink channels, and means defining an ink reservoir communicating with the ink channels. The present invention also relates to a method for manufacturing such a printhead.

An example of a conventional printhead of this type is described in EP-A-0 671 372. The ink channels are arranged side-by-side in one surface of the channel plate and extend in parallel to one another with narrow spacings formed therebetween. Each ink channel converges into a nozzle at one end thereof, so that an array of nozzles is formed, by which a plurality of ink droplets can be expelled simultaneously by energizing the actuators respectively associated with the ink channels. For a high-resolution printer, it is required that the spacings between the adjacent nozzles are made as small as possible, and, accordingly, the ink channels and the wall portions separating them must have very small dimensions in the width direction.

The ink reservoir defining means and the channel plate are formed by a one-piece substrate made of a material such as silicon, in which the ink channels can be formed by photo-lithographic etching. This has the advantage that the minute structures of the ink channels and the nozzles can be formed with high accuracy. Cavities defining the ink reservoir and supply passages connecting the ink reservoir to each of the ink channels are formed directly in the silicon substrate by etching away appropriate portions of the substrate.

As an alternative, it has been proposed to form the channel plate and the ink reservoir defining means by a one-piece block of graphite. In this case, however, the ink channels must be cut into the surface of the channel plate, and the process of forming the minute structures of the ink channels and nozzles becomes more cumbersome or a graphite with a very small grain size must be used which makes the inkjet printhead expensive.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an ink jet printhead, which can be manufactured at low costs and in which the ink channels can be formed with reproducible high accuracy.

5 According to the present invention, this object is achieved by the feature wherein the ink reservoir defining means are formed by a base member made of a material different from that of the channel plate.

As a result, it is not necessary to form the comparatively large volume of the ink reservoir in a time-consuming etching process, and the rather bulky member of the
10 printhead in which the ink reservoir is formed can be manufactured at low costs by molding, sintering or machining a rather inexpensive material such as graphite or ceramic in a relatively grainy form. Only the comparatively small volume of the channel plate is made from expensive materials such as silicon, fine grain graphite, ceramics, etc., in which the fine structures of the ink channels, and, as the case may be, the
15 nozzles, can be formed with high accuracy in an etching or mechanical process in which only a small amount of material has to be removed. Thus, not only the costs for the material but also the costs for the manufacturing process can be reduced significantly.

In a preferred embodiment the channel plate and the member defining the ink reservoir are manufactured as separate members and are then buttingly assembled
20 together and fixed to one another, e.g. by bonding, so that fluid connections between the ink reservoir and each of the ink channels are established. In this case, the ink channels can be etched or machined before the channel plate and the ink reservoir defining member are assembled, so that the apparatus needs to have only small dimensions and/or a large number of channel plates can be etched simultaneously.

25 As an alternative, it would also be possible that the etchable material, e.g. silicon, is directly deposited on a portion of the member defining the ink reservoir, and then the ink channels are formed by etching.

In a preferred design of an ink jet printhead the nozzles are arranged in two parallel rows. In this case, the ink channels associated with the respective rows of
30 nozzles can either be formed in opposite surfaces of a single channel plate or can be formed in the surfaces of separate channel plates sandwiched with a portion of the ink reservoir defining member. In the latter case, a large area of contact between the channel plates and the ink reservoir defining member is achieved, and, accordingly, there is a good thermal contact between the ink reservoir defining member and the
35 channel plates, which is particularly advantageous in case of a hot-melt printhead in

which the ink contained in the ink reservoir and the ink channels needs to be liquefied by heating.

BRIEF DESCRIPTION OF THE DRAWINGS

5 The present invention will become more fully understood from the detailed description given hereinbelow and the accompanying drawings which are given by way of illustration only, and thus are not limitative of the present invention, and wherein:

Fig. 1 is a longitudinally sectioned perspective exploded view of a printhead according to the present invention;

10 Fig. 2 is an enlarged cross-sectional view of a lower portion of the printhead shown in Figure 1, the cross-section being taken along the line II-II of Figure 1; and

Fig. 3 is a cross-sectional view of a printhead according to a modified embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

15 As is shown in Figures 1 and 2, an ink jet printhead according to the present invention has a symmetric structure and comprises as main components a base plate 10 made of graphite or ceramic and a channel plate 12 made of an etchable material, preferably a semiconductor material such as silicon. The channel plate 12 has opposite
20 lateral surfaces in which a plurality of parallel, vertically extending ink channels 14 are formed by etching. Each ink channel 14 is converged to form a nozzle 16 (figure 2) at the lower end thereof and is open at its top end. The open lateral sides of the ink channels 14 and the nozzles 16 are covered by a flexible sheet 18 made of the same material as the channel plate 12 and firmly bonded thereto. An actuator block 20 is
25 bonded to the outer surface of each sheet 18. The actuator block 20 is made of a piezoelectric ceramic material and has a comb-like structure forming a plurality of parallel, vertically extending piezoelectric fingers 22 and is provided with electrodes (not shown) associated with each of the fingers 22. A flexible lead foil 24 is attached to the outer surface of each of the actuator blocks 20 and is formed with electric leads for
30 individually energizing the piezoelectric fingers 22.

The actuator blocks 20 are protected by a cap 26 fitted over the lower end of the channel plate 12 and bonded to the lower edges of the sheets 18 and to the end faces 28 of the channel plate 12.

35 The base member 10 is a plate-like member having a comparatively thick top portion 30 in which are formed an ink reservoir 32 and a receptacle 34 for a filter

element (not shown). A lower portion 36 of the base plate 10 has a reduced thickness and width and is formed with a recess 38 extending along its lower edge. Ink supply passages 40 are symmetrically formed in the cross section of the lower portion 36 of the base plate. The ink supply passages 40 are in fluid communication with the ink reservoir 32 and are open to the bottom of the recess 38.

As is shown in Figure 2, the channel plate 12, the flexible sheets 18 and the actuator blocks 20 form a unit which is fitted to the lower edge of the base plate 10, so that the top portions of the channel plate 12 and the sheets 18 project into the recess 38. The thickness of the channel plate 12 is larger than the thickness of a web portion 42 of the base plate 10, separating the ink supply passages 40. Thus, the open ends of the ink channels 14 are in fluid communication with the ink reservoir 32 via the ink supply passages 40.

The outer surfaces of the sheets 18 projecting upwardly beyond the actuator blocks 20 are bonded to the lateral walls of the recess 38 by means of an adhesive 44, so that the ink supply passages 40 are sealed and the channel plate 12 is held in firm engagement with the web portion 42 of the base plate.

The flexible lead foils 24 are led-out on either side of the base plate 10 and are protected against tensile forces by clamping bars 46 which, together with mounting blocks 48 (figure 1) form a frame surrounding the lower portion 36 of the base plate. In the shown embodiment, the printhead is a hot-melt ink jet printhead, and, as is known per se, heating means (not shown) are provided for heating the base plate 10 so that the hot-melt ink contained in the ink reservoir 32, the ink supply passages 40 and the ink channels 14 is maintained in the liquid state. If desired, electric auxiliary heating means can be formed in the channel plate 12, for example by appropriately doping the silicon material so that resistance heating layers are formed.

When the printhead is operated, electric signals are supplied to the individual piezoelectric fingers 22 via the lead foils 24, so that the piezoelectric fingers perform expansion and retraction strokes towards and away from the associated ink channel 14, so that the sheet 18 covering this ink channel is flexed and the liquid ink contained in the ink channel is pressurized and an ink droplet is jetted-out through the nozzle 16.

As can be seen in Figures 1 and 2, the amount of bulk material needed for the base plate 10 is considerably larger than the amount of material needed for the channel plate 12. It is accordingly an important advantage of the present invention that only the comparatively small channel plate 12 needs to be made of an expensive material such as silicon. In the manufacturing process, the pattern of ink channels 14 and nozzles 16

can be formed with high precision in both lateral surfaces of the channel plate 12 by using photo-lithographic etching techniques. Then, the ink channels are covered with the flexible sheets 18 and the actuator blocks 20 are secured thereto by bonding. The fact that, at this stage, the channel plate 12 is not yet fitted to the base plate 10, facilitates the fine adjustment of the piezoelectric fingers 22 of the actuator blocks relative to the ink channels 14. Finally, the unit formed by the channel plate, the flexible sheets 18 and the actuator blocks 20 is fitted to the base plate 10 and secured thereto by bonding.

Figure 3 shows a modified embodiment in which the web portion 42 of the base plate 10, instead of forming the recess 38 shown in Figure 2, is extended to form a support plate 48 sandwiched between two separate channel plates 12. In this embodiment, the amount of silicon material required for forming the two channel plates is even smaller than in the case of Figure 2, and each channel plate forms only one row of ink channels 14. The thickness of the support plate 48 is preferably smaller than that of the web portion 42, so that the channel plates can be abutted against a shoulder formed between the support plate 48 and the web portion 42. The flexible sheets 18 are in this case made from slightly thicker plates which are in abutting engagement with the lower edge of the base plate 10 on either side of the projecting support plate 48 and from which a central portion has been etched away in order to accommodate the actuator blocks 20 and to provide the required flexibility.

The channel plates 12 are secured to the surfaces of the support plate 48 by means of an adhesive, which provides for a good thermal contact between the base plate 10 and the channel plates.

It is possible to use graphite for the base member 10 and the channel plate 12. In this situation graphite with carbon particles having a grain size greater than $10\text{ }\mu\text{m}$ is used for the base member 10 and for the channel plate 12, graphite with carbon particles having a grain size smaller than $10\text{ }\mu\text{m}$, preferably smaller than $3\text{ }\mu\text{m}$, is utilized.

Although only specific embodiments of the present invention have been described above, it will be clear for a person skilled in the art that various modifications and changes can be made within the scope of the appended claims.

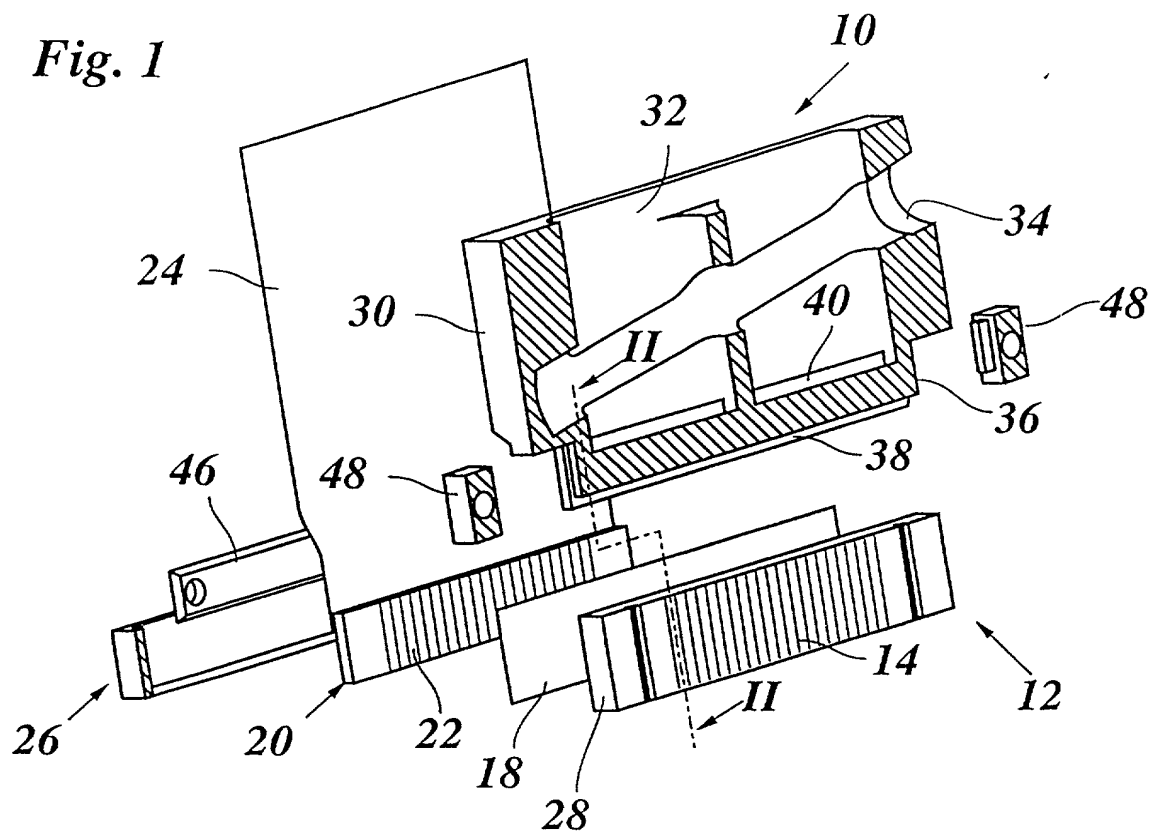
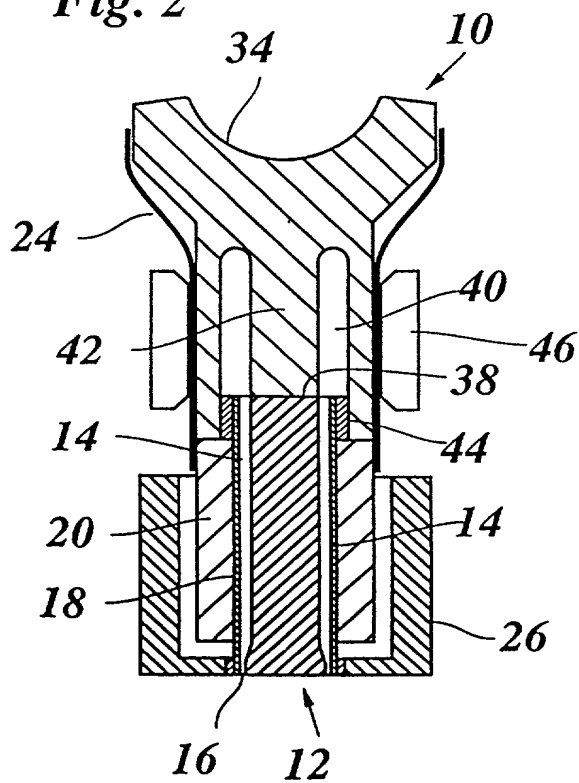
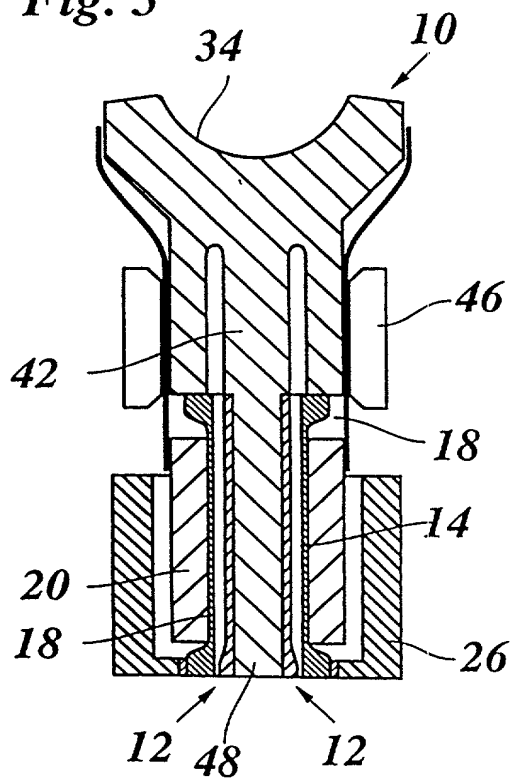
WHAT IS CLAIMED IS:

1. An Ink jet printhead comprising
5 a channel plate having a plurality of ink channels etched into at least one surface thereof,
actuators respectively associated with each of the ink channels for pressurizing ink contained in the ink channels, and
means defining an ink reservoir communicating with the ink channels, wherein
10 said ink reservoir is defined by a base member made of a material different from that of the channel plate.
2. The Ink jet printhead according to claim 1, wherein the channel plate is held in
15 butting engagement with a surface of the base member in which an ink supply passage is formed for establishing fluid communication between the ink reservoir and the ink channels.
3. The Ink jet printhead according to claim 1, wherein the channel plate is fixed to
20 the base member by means of an adhesive.
4. The Ink jet printhead according to claim 1, wherein the base member is made
of graphite.
5. The Ink jet printhead according to claim 1, wherein the channel plate is made
25 of silicon.
6. The Ink jet printhead according to claim 1, wherein a portion of the base
member forms a support plate sandwiched between two separate channel plates.
- 30 7. A method of manufacturing an ink jet printhead having a channel plate provided on at least one surface with a plurality of ink channels, a flexible sheet for covering the open sides of the ink channels, and an actuator block forming a plurality of actuators, which comprises assembling the channel plate, the flexible sheet and the actuator block together to form a unit which is then fitted to a base member.

ABSTRACT OF THE DISCLOSURE

An Ink jet printhead comprising a channel plate having a plurality of ink channels etched into at least one surface thereof, actuators respectively associated with each of
5 the ink channels for pressurizing ink contained in the ink channels, and means defining an ink reservoir communicating with the ink channels, wherein said ink reservoir is defined by a base member made of a material different from that of the channel plate.

0044743-883460

Fig. 1*Fig. 2**Fig. 3*

BIRCH, STEWART, KOLASCH & BIRCH, LLP

P.O. Box 747 • Falls Church, Virginia 22040-0747
Telephone: (703) 205-8000 • Facsimile: (703) 205-8050

142-309P

PLEASE NOTE:
YOU MUST
COMPLETE THE
FOLLOWING

COMBINED DECLARATION AND POWER OF ATTORNEY FOR PATENT AND DESIGN APPLICATIONS

As a below named inventor, I hereby declare that: my residence, post office address and citizenship are as stated next to my name; that I verily believe that I am the original, first and sole inventor (if only one inventor is named below) or an original, first and joint inventor (if plural inventors are named below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Insert Title:

INKJET PRINTHEAD

Fill in Appropriate
Information -
For Use Without
Specification
Attached:

the specification of which is attached hereto. If not attached hereto,
the specification was filed on _____ as
United States Application Number _____;
and amended on _____ (if applicable) and/or
the specification was filed on _____ as PCT
International Application Number _____; and was
amended under PCT Article 19 on _____ (if applicable)

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, §1.56.

I do not know and do not believe the same was ever known or used in the United States of America before my or our invention thereof, or patented or described in any printed publication in any country before my or our invention thereof or more than one year prior to this application, that the same was not in public use or on sale in the United States of America more than one year prior to this application, that the invention has not been patented or made the subject of an inventor's certificate issued before the date of this application in any country foreign to the United States of America on an application filed by me or my legal representative or assigns more than twelve months (six months for designs) prior to this application, and that no application for patent or inventor's certificate on this invention has been filed in any country foreign to the United States of America prior to this application by me or my legal representatives or assigns, except as follows.

I hereby claim foreign priority benefits under Title 35, United States Code, §119(a)-(d) of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)

Priority Claimed

Insert Priority
Information:
(if appropriate)

<u>99200195.8</u> (Number)	<u>Europe</u> (Country)	<u>January 22, 1999</u> (Month/Day/Year Filed)	<input checked="" type="checkbox"/> Yes	<input type="checkbox"/> No
<u> </u> (Number)	<u> </u> (Country)	<u> </u> (Month/Day/Year Filed)	<input type="checkbox"/> Yes	<input type="checkbox"/> No
<u> </u> (Number)	<u> </u> (Country)	<u> </u> (Month/Day/Year Filed)	<input type="checkbox"/> Yes	<input type="checkbox"/> No
<u> </u> (Number)	<u> </u> (Country)	<u> </u> (Month/Day/Year Filed)	<input type="checkbox"/> Yes	<input type="checkbox"/> No

I hereby claim the benefit under Title 35, United States Code, §119(e) of any United States provisional applications(s) listed below.

Insert Provisional
Application(s):
(if any)

<u> </u> (Application Number)	<u> </u> (Filing Date)
<u> </u> (Application Number)	<u> </u> (Filing Date)

All Foreign Applications, if any, for any Patent or Inventor's Certificate Filed More than 12 Months (6 Months for Designs) Prior to the Filing Date of This Application:

Country	Application Number	Date of Filing (Month/Day/Year)
<u> </u>	<u> </u>	<u> </u>
<u> </u>	<u> </u>	<u> </u>

Insert Requested
Information:
(if appropriate)

I hereby claim the benefit under Title 35, United States Code, §120 of any United States and/or PCT application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States and/or PCT application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose information which is material to the patentability as defined in Title 37, Code of Federal Regulations, §1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

Insert Prior U.S.
Application(s):
(if any)

<u> </u> (Application Number)	<u> </u> (Filing Date)	<u> </u> (Status - patented, pending, abandoned)
<u> </u> (Application Number)	<u> </u> (Filing Date)	<u> </u> (Status - patented, pending, abandoned)

I hereby appoint the following attorneys to prosecute this application and/or an international application based on this application and to transact all business in the Patent and Trademark Office connected therewith and in connection with the resulting patent based on instructions received from the entity who first sent the application papers to the attorneys identified below, unless the inventor(s) or assignee provides said attorneys with a written notice to the contrary:

Raymond C. Stewart	(Reg. No. 21,066)	Terrell C. Birch	(Reg. No. 19,382)
Joseph A. Kolasch	(Reg. No. 22,463)	James M. Slattery	(Reg. No. 28,380)
Bernard L. Sweeney	(Reg. No. 24,448)	Michael K. Mutter	(Reg. No. 29,680)
Charles Gorenstein	(Reg. No. 29,271)	Gerald M. Murphy, Jr.	(Reg. No. 28,977)
Leonard R. Svensson	(Reg. No. 30,330)	Terry L. Clark	(Reg. No. 32,644)
Andrew D. Meikle	(Reg. No. 32,868)	Marc S. Weiner	(Reg. No. 32,181)
Joe McKinney Muncy	(Reg. No. 32,334)	Donald J. Daley	(Reg. No. 34,313)
John W. Bailey	(Reg. No. 32,881)	John A. Castellano	(Reg. No. 35,094)

Send Correspondence to:

BIRCH, STEWART, KOLASCH & BIRCH, LLP

P.O. Box 747 • Falls Church, Virginia 22040-0747

or

Customer No. 2292

Telephone: (703) 205-8000 • Facsimile: (703) 205-8050

PLEASE NOTE:
YOU MUST
COMPLETE
THE
FOLLOWING:



I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full Name of First
or Sole Inventor:
Insert Name of
Inventor →
Insert Date This
Document is Signed

Insert Residence
Insert Citizenship →

Insert Post Office
Address →

Full Name of Second
Inventor, if any:
see above

Full Name of Third
Inventor, if any:
see above

Full Name of Fourth
Inventor, if any:
see above

Full Name of Fifth
Inventor, if any:
see above

GIVEN NAME/FAMILY NAME Peter Joseph HOLLANDS	INVENTOR'S SIGNATURE <i>Peter Joseph Hollands</i>	DATE* 12-22-99
Residence (City, State & Country) Baarlo, The Netherlands	CITIZENSHIP The Netherlands	
POST OFFICE ADDRESS (Complete Street Address including City, State & Country) Diepenbroeklaan 11, 5991 PT Baarlo, The Netherlands		
GIVEN NAME/FAMILY NAME Hendrik Willem ELLENKAMP	INVENTOR'S SIGNATURE <i>Hendrik Willem Ellenkamp</i>	DATE* 12-23-99
Residence (City, State & Country) Venlo, The Netherlands	CITIZENSHIP The Netherlands	
POST OFFICE ADDRESS (Complete Street Address including City, State & Country) Wijnbergstraat 4, 5913 CA Venlo, The Netherlands		
GIVEN NAME/FAMILY NAME	INVENTOR'S SIGNATURE	DATE*
Residence (City, State & Country)	CITIZENSHIP	
POST OFFICE ADDRESS (Complete Street Address including City, State & Country)		
GIVEN NAME/FAMILY NAME	INVENTOR'S SIGNATURE	DATE*
Residence (City, State & Country)	CITIZENSHIP	
POST OFFICE ADDRESS (Complete Street Address including City, State & Country)		
GIVEN NAME/FAMILY NAME	INVENTOR'S SIGNATURE	DATE*
Residence (City, State & Country)	CITIZENSHIP	
POST OFFICE ADDRESS (Complete Street Address including City, State & Country)		

*DATE OF SIGNATURE